(12) UK Patent Application (19) GB (11) 2 071 853 A

(21) Application No 8106878
(22) Date of filing
5 Mar 1981
(30) Priority data
(31) 3008572
3009811
(32) 6 Mar 1980
14 Mar 1980
(33) Fed Rep of Germany
(DE)
(43) Application published
23 Sep 1981
(51) INT CL³ G01L 7/08
9/04 9/12 // 23/24
(52) Domestic classification
G1N 1A3A 1A3B 1D2B
1D5 1F 7C AGA
H1K 1FC 5A4 5B1 5C3D
5E4 5L 5R PX
(56) Documents cited
None
(58) Field of search
G1N
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(54) Pressure sensor

(57) A pressure sensor comprises a pressure deflectable diaphragm 2, formed on a substrate 1 by a thick-film technique and rigidly connected to the substrate during the forming process, details of which are given. The sensing elements can be either capacitative (Fig. 1) for thick-layer resistors R1, R2 whose resistance is a measure of the deflection of the diaphragm. The sensor may be used to sense the air intake pressure in an internal combustion engine.

FIG.2

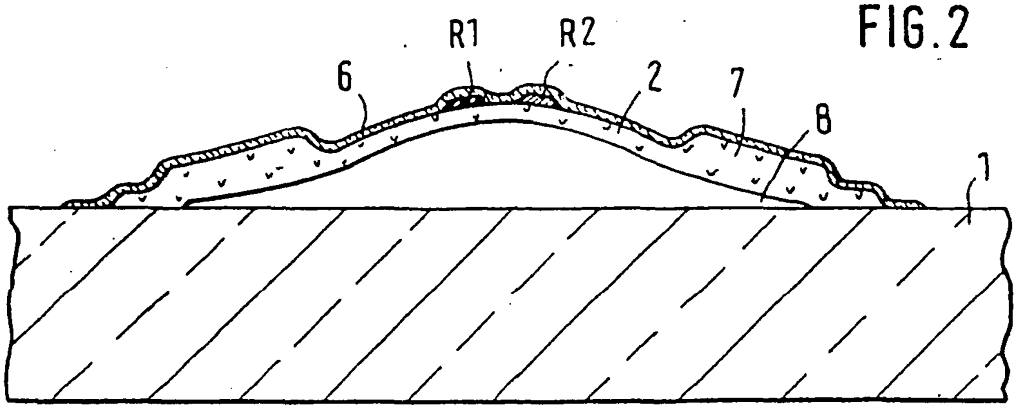

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FIG.1

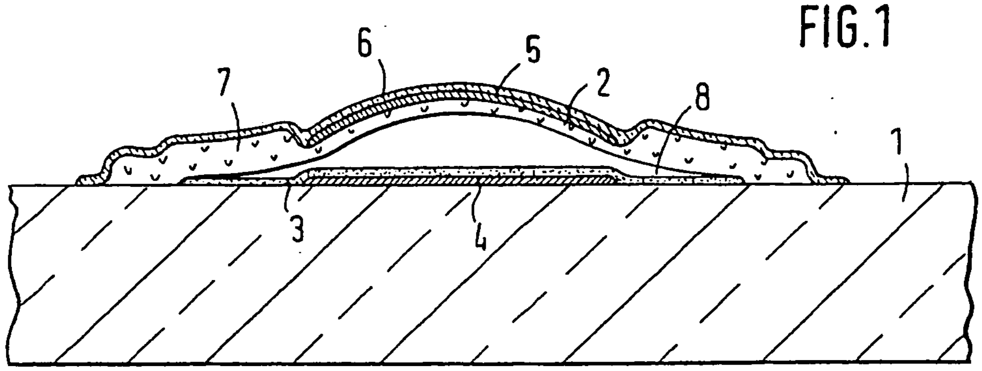
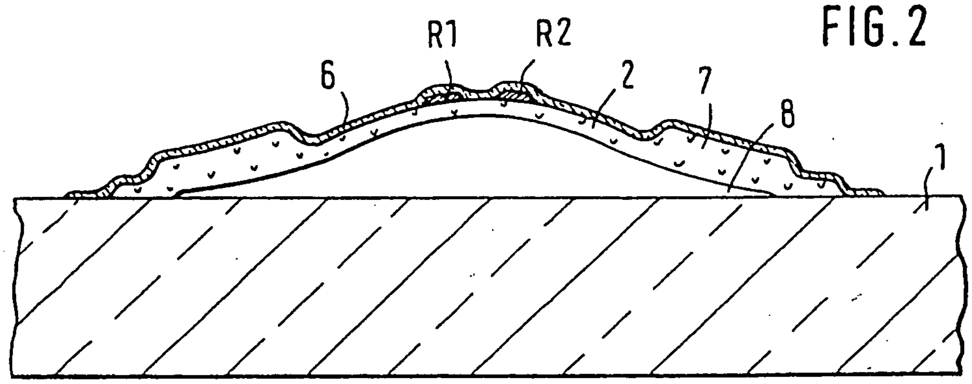


FIG.2



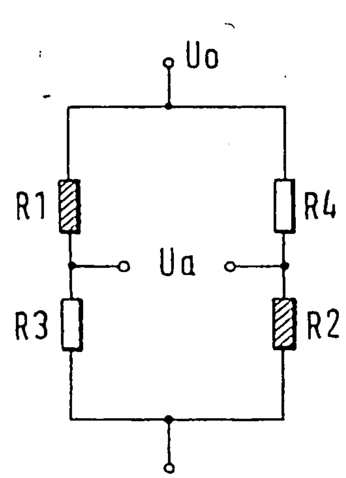


FIG.3

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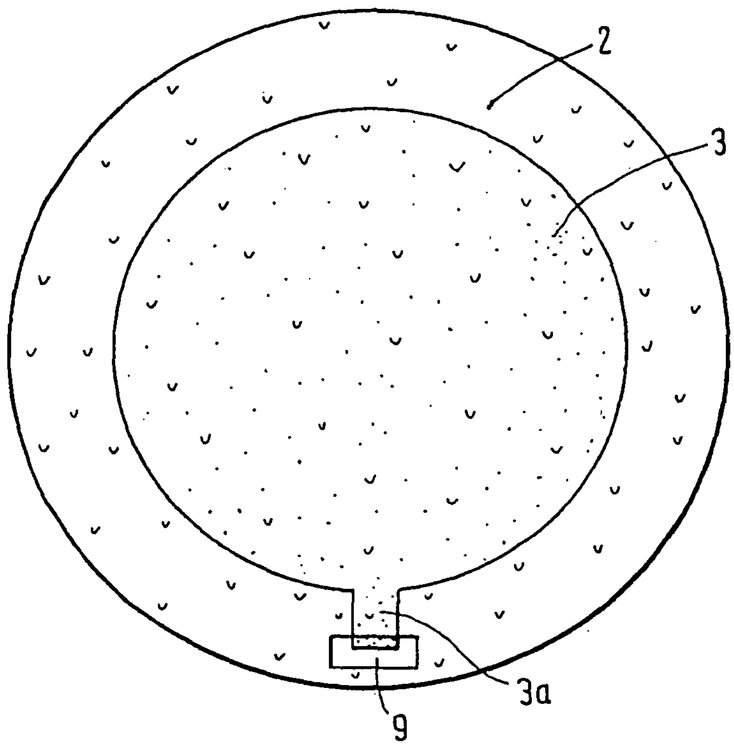

FIG.4

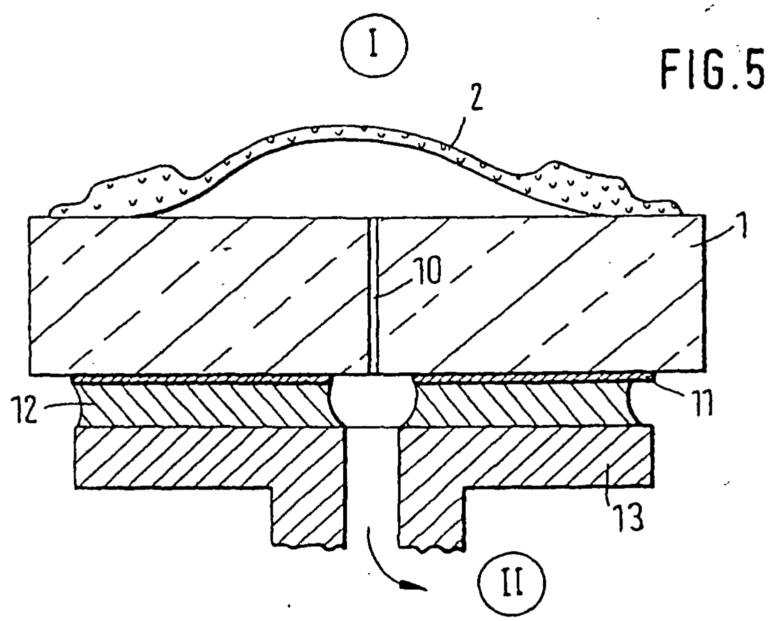

FIG.5

SPECIFICATION

Pressure sensing box

The invention relates to a pressure box for use e.g. in sensing the intake air pressure in an internal combustion engine, and comprising a pressure-deflectable diaphragm.

Such boxes, which are of small dimensions, convert the sensed pressure values into electrical signals which can be readily further processed for controlling and/or regulating the internal combustion engine, and are required to work for long periods of operation.

In order to provide a reliable box, the present invention entails forming the diaphragm on a substrate by the thick film technique.

There is provided by the present invention a pressure box having a pressure deflectable diaphragm, wherein the diaphragm is formed on a substrate by the thick-film technique and is rigidly connected to the substrate in the forming process.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a cross-sectional view of a pressure sensing box according to the present invention partly formed;

Figure 2 is a like section of a further pressure sensing box according to the present invention in a finished form;

Figure 3 shows resistance elements incorporated in the box of Fig. 2 as part of an electrical circuit;

Figure 4 is a plan view of a modified detail of the box of Fig. 1, and

Figure 5 is a cross section of a modification of the embodiments of Figs. 1 and 2.

Referring to the first embodiment shown in section in Fig. 1, a metal layer 4 which is manufactured preferably by the printing and burning method of thick-layer technology or which is applied by vapour deposition, is applied to a substrate wafer 1 which is approximately 1 cm in diameter and which is made from ceramic material or glass or which comprises a metal wafer whose upper side is enamelled, the metal layer being covered by a diaphragm 2 disposed at a distance therefrom. The diaphragm 2 in this instance is approximately 60 μ thick, has a diameter of approximately 0.5 cm, and is made from a ceramic material, preferably glass ceramic, which is applied in the form of a paste by the screen printing method. A filler 3 made from, for example, carbon black with organic additives, is applied by printing in order to be able to maintain a cavity in the region of the pressure box between the diaphragm 2 and the metal layer 4. During the subsequent sintering operation, which is performed at temperatures of about 950° under a protective gas atmosphere, this filler prevents the printed-on ceramic material of the diaphragm 2 from being bonded to the substrate 1 in the region of the pressure box, and the ceramic material of the diaphgram 2 at the same time fuses together to form a solid but deformable mass.

The filler 3 is then burnt in a second burning operation under an oxidizing atmosphere so as to leave no residues, it being important that the diaphragm 2 of glass ceramics should have been made sufficiently thin and should not be too imporous. This also effects shaping of the diaphragm, i.e. to assume the domed form shown in Fig. 2. The self-supporting diaphragm is reinforced to the desired thickness during following printing and burning operations, and the cavity which has been formed is sealed in a gas-tight manner by applying a further layer 6 such as an amorphous layer of glass.

If the material chosen for the diaphragm 2 is a material whose coefficient of thermal expansion is greater than that of the substrate 1, the diaphragm forms, after the burning operation, a support surface which bulges away from the substrate 1. In this instance, the layer 3 would not be needed for this purpose. As a result, the diaphragm would have an inherent stress to permit the box to be used for the measurement of vacuum. It is thereby ensured that the diaphragm is always subjected to compressive stress, thus avoiding tensile stresses to which, as is common knowledge, the ceramic or vitreous masses are less resistant.

The periphery of the diaphragm 2 bulges at a very small angle 8 as a result of thickening the annular edge zone 7 of the diaphragm 2, whereby the fatigue strength of the diaphragm 2 is significantly increased during movements of the diaphragm which occur during operation.

If, in the box shown in plan view in Fig. 4, a protuberance 9*a* is provided when printing the filler 3, and the region 9 remains free from material when printing the diaphragm 2, the pressure box thus formed can be evacuated or filled with a defined gas pressure. Thus, after the filler 3 has been burnt, there is formed in the region 3*a* a tunnel which, after all the elements have been finished, is then closed in the region 9 in a furnace at a defined gas pressure by, for example, the melting-on of glass-containing paste.

In the embodiment of Fig. 1, the deformable diaphragm 2 subjected to under- or overpressure forms part of a variable air capacitor. For this purpose, a conductor surface 5 is applied to the diaphragm and forms the capacitor together with the metal layer 4. The greater the pressure which acts upon the diaphragm 2, and which reduces the distance between the conductor surface 5 and the metal layer 4, the greater is the capacitance of the capacitor.

In the embodiment of Fig. 2, conductor layers, resistance layers and glass or glass ceramic layers are applied successively to the self-supporting glass ceramic diaphragm 2 by the printing and burning method of thin- or thick-layer technology. In the illustrated embodiment, two resistors R1 and R2 are applied to the diaphragm 2 by means of the thick-layer technique and are covered by the glass layer 6.

The two resistors R1 and R2 are expanded or compressed upon changes in the air pressure acting upon the diaphragm 2. The electrical resistance value of suitable thick-layer resistors then varies to a considerable extent, and the thick-layer resistors can be used to advantage in a bridge arrangement which is illustrated in Fig. 3 and in which each of the said resistors is connected in series with one of two fixed resistors R3 or R4 in a respective one of two diametrically opposite bridge arms.

The illustrated bridge circuit has the great advantage that the two bridge resistors R3 and R4 not disposed on the diaphragm 2 can be adjusted by known methods, particularly by means of laser beams, whilst the measuring box is located in an atmosphere having a defined pressure. This is of great advantage with respect to manufacturing technology, since the output voltage Ua can be calibrated simply and rapidly irrespective of the pressure in the pressure box and irrespective of the state of stress of the diaphragm 2.

When the substrate 1 below the diaphragm 2 has a small bore 10 through which the interior of the pressure box communicates with the gas chamber II, the box which has been described can also be used to measure the pressure difference between two gas chambers I and II, as is shown in Fig. 5. By way of example, a further annular metal coat 11 can be applied to the back of the substrate 1 and can be connected to the supports 13 by a soldered joint 12.

A diaphragm made of glass ceramic may be 20 to 300 μ thick.

Altogether, the construction, in accordance with the invention, of the pressure box has the following advantages:—

Sensor elements (resistors or capacitor electrodes) are rigidly integrated in the diaphragm of the pressure box, thus dispensing with transmission elements which are prone to trouble.

The pressure box and sensor elements are integrated on a substrate on which further electrical circuit elements can be disposed by known methods of thick-layer hybrid technology.

Miniaturised construction of the aneroid box is made possible.

All the steps in the manufacture of the sensor are performed at high temperatures (500–950°). It is thus possible to use the sensor at an elevated temperature.

Automatable and thus inexpensive manufacturing methods of thick-layer technology are used and the material costs are low.

CLAIMS

1. A pressure box having a pressure deflectable diaphragm, wherein the diaphragm is formed on a substrate by the thick-film technique and is rigidly connected to the substrate in the forming process.

2. A box as claimed in claim 1, wherein the substrate is of wafer-like construction.

3. A box as claimed in claim 1 or 2, wherein the substrate is made from ceramic material, glass or enamelled metal.

4. A box as claimed in any of the claims 1 to 3, wherein the diaphragm is made from glass ceramic and is approximately 20 to 300 μ thick and preferably some 100 μ thick.

5. A box as claimed in any of the claims 1 to 4, wherein the curvature of the diaphragm is convex in the central portion of the measuring box, but is concave at the periphery.

6. A box as claimed in any of the claims 1 to 5, wherein there is provided a tunnel-like cavity through which the measuring box is evacuated or filled at a defined gas pressure and which is thereafter sealed by a vitreous mass.

7. A box as claimed in any of the claims 1 to 6, wherein the outside of the diaphragm carries a metal electrode which is located opposite, and spaced from, a metal layer disposed directly on the substrate.

8. A box as claimed in any of the claims 1 to 6, wherein there is disposed on the outside of the diaphragm at least one resistor which is applied by thin- or thick-layer technique and whose resistance value varies in dependence upon pressure.

9. A box as claimed in claims 7 and 8, wherein the substrate has a bore below the diaphragm.

10. A box as claimed in claims 7 to 9, wherein the diaphragm is covered by a coating which surrounds the resistor or the metal electrode as the case may be.

11. A box as claimed in claim 10, wherein said coating is of glass.

12. A pressure box substantially as hereinbefore described with reference to Fig. 1, Figs. 2 and 3, Fig. 4 or Fig. 5 of the accompanying drawings.

Printed for Her Majesty's Stationery Office
by Burgess & Son (Abingdon) Ltd.—1981.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.